

## IN THE CLAIMS

1-19 (Canceled) ↘

20. (Previously Presented) A human glycoprotein hormone family protein comprising at least one electrostatic charge altering mutation in a  $\beta$  hairpin loop structure of a human chorionic gonadotropin (CG)  $\beta$  subunit, wherein the at least one electrostatic charge altering mutation is in the L1  $\beta$  hairpin loop at a position selected from the group consisting of positions 1-37 or 58-87 as shown in SEQ ID NO:3, wherein the at least one electrostatic charge altering mutation comprises at least one basic residue introducing mutation selected from the group consisting of S1B, E3B, P4B, L5B, P7B, R8B, C9B, P11B, I12B, N13B, A14B, T15B, L16B, A17B, V18B, E19B, G22B, C23B, V25B, C26B, I27B, T28B, V29B, N30B, T31B, T32B, I33B, C34B, A35B, G36B, Y37B, N58B, Y59B, D61B, V62B, F64B, S66B, I67B, L69B, P70B, P73B, V76B, N77B, V80B, S81B, Y82B, A83B, V84B, A85B, L86B, and S87B, wherein B is a basic amino acid residue, or wherein the at least one electrostatic charge altering mutation comprises at least one acidic residue introducing mutation selected from the group consisting of S1Z, K2Z, P4Z, L5Z, R6Z, P7Z, R8Z, C9Z, R10Z, P11Z, I12Z, N13Z, A14Z, T15Z, L16Z, A17Z, V18Z, K20Z, C23Z, P24Z, V25Z, C26Z, I27Z, T28Z, V29Z, N30Z, T31Z, T32Z, I33Z, C34Z, A35Z, G36Z, Y37Z, N58Z, Y59Z, R60Z, V62Z, R63Z, F64Z, S66Z, I67Z, L69Z, P70Z, G71Z, C72Z, P73Z, R74Z, G75Z, V76Z, V79Z, V80Z, S81Z, Y82Z, A83Z, V84Z, A85Z, L86Z, and S87Z wherein Z is an acidic amino acid residue, or wherein the at least one electrostatic charge altering mutation comprises at least one neutral residue introducing mutation selected from the group consisting of K2U, E3U, R10U, E19U, E21U, R60U, D61U, R63U, E65U, and R68U wherein U is a neutral amino acid.

21. (Previously Presented) The protein according to Claim 20, wherein the mutation is a basic residue introducing mutation.

22. (Previously Presented) The protein according to Claim 21, wherein the mutation is S1B.
23. (Previously Presented) The protein according to Claim 21, wherein the mutation is E3B.
24. (Previously Presented) The protein according to Claim 21, wherein the mutation is P4B.
25. (Previously Presented) The protein according to Claim 21, wherein the mutation is L5B.
26. (Previously Presented) The protein according to Claim 21, wherein the mutation is P7B.
27. (Previously Presented) The protein according to Claim 21, wherein the mutation is R8B.
28. (Previously Presented) The protein according to Claim 21, wherein the mutation is C9B.
29. (Previously Presented) The protein according to Claim 21, wherein the mutation is P11B.
30. (Previously Presented) The protein according to Claim 21, wherein the mutation is I12B.
31. (Previously Presented) The protein according to Claim 21, wherein the mutation is N13B.
32. (Previously Presented) The protein according to Claim 21, wherein the mutation is A14B.
33. (Previously Presented) The protein according to Claim 21, wherein the mutation is T15B.

34. (Previously Presented) The protein according to Claim 21, wherein the mutation is L16B.
35. (Previously Presented) The protein according to Claim 21, wherein the mutation is A17B.
36. (Previously Presented) The protein according to Claim 21, wherein the mutation is V18B.
37. (Previously Presented) The protein according to Claim 21, wherein the mutation is E19B.
38. (Previously Presented) The protein according to Claim 21, wherein the mutation is G22B.
39. (Previously Presented) The protein according to Claim 21, wherein the mutation is C23B.
40. (Previously Presented) The protein according to Claim 21, wherein the mutation is V25B.
41. (Previously Presented) The protein according to Claim 21, wherein the mutation is C26B.
42. (Previously Presented) The protein according to Claim 21, wherein the mutation is I27B.
43. (Previously Presented) The protein according to Claim 21, wherein the mutation is T28B.
44. (Previously Presented) The protein according to Claim 21, wherein the mutation is V29B.
45. (Previously Presented) The protein according to Claim 21, wherein the mutation is N30B.

46. (Previously Presented) The protein according to Claim 21, wherein the mutation is T31B.
47. (Previously Presented) The protein according to Claim 21, wherein the mutation is T32B.
48. (Previously Presented) The protein according to Claim 21, wherein the mutation is I33B.
49. (Previously Presented) The protein according to Claim 21, wherein the mutation is C34B.
50. (Previously Presented) The protein according to Claim 21, wherein the mutation is A35B.
51. (Previously Presented) The protein according to Claim 21, wherein the mutation is G36B.
52. (Previously Presented) The protein according to Claim 21, wherein the mutation is Y37B.
53. (Previously Presented) The protein according to Claim 21, wherein the mutation is N58B.
54. (Previously Presented) The protein according to Claim 21, wherein the mutation is Y59B.
55. (Previously Presented) The protein according to Claim 21, wherein the mutation is D61B.
56. (Previously Presented) The protein according to Claim 21, wherein the mutation is V62B.
57. (Previously Presented) The protein according to Claim 21, wherein the mutation is F64B.

58. (Previously Presented) The protein according to Claim 21, wherein the mutation is S66B.
59. (Previously Presented) The protein according to Claim 21, wherein the mutation is I67B.
60. (Previously Presented) The protein according to Claim 21, wherein the mutation is L69B.
61. (Previously Presented) The protein according to Claim 21, wherein the mutation is P70B.
62. (Previously Presented) The protein according to Claim 21, wherein the mutation is P73B.
63. (Previously Presented) The protein according to Claim 21, wherein the mutation is V76B.
64. (Previously Presented) The protein according to Claim 21, wherein the mutation is N77B.
65. (Previously Presented) The protein according to Claim 21, wherein the mutation is V80B.
66. (Previously Presented) The protein according to Claim 21, wherein the mutation is S81B.
67. (Previously Presented) The protein according to Claim 21, wherein the mutation is Y82B.
68. (Previously Presented) The protein according to Claim 21, wherein the mutation is A83B.
69. (Previously Presented) The protein according to Claim 21, wherein the mutation is V84B.

70. (Previously Presented) The protein according to Claim 21, wherein the mutation is A85B.
71. (Previously Presented) The protein according to Claim 21, wherein the mutation is L86B.
72. (Previously Presented) The protein according to Claim 21, wherein the mutation is S87B.
73. (Previously Presented) The protein according to Claim 20, wherein the mutation is an acidic residue introducing mutation.
74. (Previously Presented) The protein according to Claim 73, wherein the mutation is S1Z.
75. (Previously Presented) The protein according to Claim 73, wherein the mutation is K2Z.
76. (Previously Presented) The protein according to Claim 73, wherein the mutation is P4Z.
77. (Previously Presented) The protein according to Claim 73, wherein the mutation is L5Z.
78. (Previously Presented) The protein according to Claim 73, wherein the mutation is R6Z.
79. (Previously Presented) The protein according to Claim 73, wherein the mutation is P7Z.
80. (Previously Presented) The protein according to Claim 73, wherein the mutation is R8Z.
81. (Previously Presented) The protein according to Claim 73, wherein the mutation is C9Z.

82. (Previously Presented) The protein according to Claim 73, wherein the mutation is R10Z.

83. (Previously Presented) The protein according to Claim 73, wherein the mutation is P11Z.

84. (Previously Presented) The protein according to Claim 73, wherein the mutation is I12Z.

85. (Previously Presented) The protein according to Claim 73, wherein the mutation is N13Z.

86. (Previously Presented) The protein according to Claim 73, wherein the mutation is A14Z.

87. (Previously Presented) The protein according to Claim 73, wherein the mutation is T15Z.

88. (Previously Presented) The protein according to Claim 73, wherein the mutation is L16Z.

89. (Previously Presented) The protein according to Claim 73, wherein the mutation is A17Z.

90. (Previously Presented) The protein according to Claim 73, wherein the mutation is V18Z.

91. (Previously Presented) The protein according to Claim 73, wherein the mutation is K20Z.

92. (Previously Presented) The protein according to Claim 73, wherein the mutation is C23Z.

93. (Previously Presented) The protein according to Claim 73, wherein the mutation is P24Z.

94. (Previously Presented) The protein according to Claim 73, wherein the mutation is V25Z.
95. (Previously Presented) The protein according to Claim 73, wherein the mutation is C26Z.
96. (Previously Presented) The protein according to Claim 73, wherein the mutation is I27Z.
97. (Previously Presented) The protein according to Claim 73, wherein the mutation is T28Z.
98. (Previously Presented) The protein according to Claim 73, wherein the mutation is V29Z.
99. (Previously Presented) The protein according to Claim 73, wherein the mutation is N30Z.
100. (Previously Presented) The protein according to Claim 73, wherein the mutation is T31Z.
101. (Previously Presented) The protein according to Claim 73, wherein the mutation is T32Z.
102. (Previously Presented) The protein according to Claim 73, wherein the mutation is I33Z.
103. (Previously Presented) The protein according to Claim 73, wherein the mutation is C34Z.
104. (Previously Presented) The protein according to Claim 73, wherein the mutation is A35Z.
105. (Previously Presented) The protein according to Claim 73, wherein the mutation is G36Z.



106. (Previously Presented) The protein according to Claim 73, wherein the mutation is Y37Z.
107. (Previously Presented) The protein according to Claim 73, wherein the mutation is N58Z.
108. (Previously Presented) The protein according to Claim 73, wherein the mutation is Y59Z.
109. (Previously Presented) The protein according to Claim 73, wherein the mutation is R60Z.
110. (Previously Presented) The protein according to Claim 73, wherein the mutation is V62Z.
111. (Previously Presented) The protein according to Claim 73, wherein the mutation is R63Z.
112. (Previously Presented) The protein according to Claim 73, wherein the mutation is F64Z.
113. (Previously Presented) The protein according to Claim 73, wherein the mutation is S66Z.
114. (Previously Presented) The protein according to Claim 73, wherein the mutation is I67Z.
115. (Previously Presented) The protein according to Claim 73, wherein the mutation is L69Z.
116. (Previously Presented) The protein according to Claim 73, wherein the mutation is P70Z.
117. (Previously Presented) The protein according to Claim 73, wherein the mutation is G71Z.

118. (Previously Presented) The protein according to Claim 73, wherein the mutation is C72Z.
119. (Previously Presented) The protein according to Claim 73, wherein the mutation is P73Z.
120. (Previously Presented) The protein according to Claim 73, wherein the mutation is R74Z.
121. (Previously Presented) The protein according to Claim 73, wherein the mutation is G75Z.
122. (Previously Presented) The protein according to Claim 73, wherein the mutation is V76Z.
123. (Previously Presented) The protein according to Claim 73, wherein the mutation is V79Z.
124. (Previously Presented) The protein according to Claim 73, wherein the mutation is V80Z.
125. (Previously Presented) The protein according to Claim 73, wherein the mutation is S81Z.
126. (Previously Presented) The protein according to Claim 73, wherein the mutation is Y82Z.
127. (Previously Presented) The protein according to Claim 73, wherein the mutation is A83Z.
128. (Previously Presented) The protein according to Claim 73, wherein the mutation is V84Z.
129. (Previously Presented) The protein according to Claim 73, wherein the mutation is A85Z.

130. (Previously Presented) The protein according to Claim 73, wherein the mutation is L86Z.
131. (Previously Presented) The protein according to Claim 73, wherein the mutation is S87Z.
132. (Previously Presented) The protein according to Claim 20, wherein the mutation is a neutral residue introducing mutation.
133. (Previously Presented) The protein according to Claim 132, wherein the mutation is K2U.
134. (Previously Presented) The protein according to Claim 132, wherein the mutation is E3U.
135. (Previously Presented) The protein according to Claim 132, wherein the mutation is R10U.
136. (Previously Presented) The protein according to Claim 132, wherein the mutation is E19U.
137. (Previously Presented) The protein according to Claim 132, wherein the mutation is E21U.
138. (Previously Presented) The protein according to Claim 132, wherein the mutation is R60U.
139. (Previously Presented) The protein according to Claim 132, wherein the mutation is D61U.
140. (Previously Presented) The protein according to Claim 132, wherein the mutation is R63U.
141. (Previously Presented) The protein according to Claim 132, wherein the mutation is E65U.

142. (Previously Presented) The protein according to Claim 132, wherein the mutation is R68U.

143. (Previously Presented) A human glycoprotein hormone family protein comprising a  $\beta$  hairpin loop structure of a human chorionic gonadotropin (CG)  $\beta$  subunit, as shown in SEQ ID NO: 3, having at least one mutation not in the  $\beta$  hairpin loop structure, and the at least one mutation is selected from the group consisting of C38J, P39J, T40J, M41J, T42J, R43J, V44J, L45J, Q46J, G47J, V48J, L49J, P50J, A51J, L52J, P53J, Q54J, V55J, V56J, C57J, C88J, Q89J, C90J, A91J, L92J, C93J, R94J, R95J, S96J, T97J, T98J, D99J, C100J, G101J, G102J, P103J, K104J, D105J, H106J, P107J, L108J, T109J, C110J, D111J, D112J, P113J, R114J, F115J, Q116J, D117J, S118J, S119J, S120J, S121J, K122J, A123J, P124J, P125J, P126J, S127J, L128J, P129J, S130J, P131J, S132J, R133J, L134J, P135J, G136J, P137J, S138J, D139J, and T140J, wherein the variable J is any amino acid whose introduction results in an increase in the electrostatic interaction between an L1 and L3  $\beta$  hairpin loop structure of the hCG  $\beta$ -subunit and a receptor with affinity for a dimeric protein containing the mutant hCG  $\beta$ -subunit monomer.

144. (Previously Presented) The protein according to Claim 143, wherein the mutation is C38J.

145. (Previously Presented) The protein according to Claim 143, wherein the mutation is P39J.

146. (Previously Presented) The protein according to Claim 143, wherein the mutation is T40J.

147. (Previously Presented) The protein according to Claim 143, wherein the mutation is M41J.

148. (Previously Presented) The protein according to Claim 143, wherein the mutation is T42J.

149. (Previously Presented) The protein according to Claim 143, wherein the mutation is R43J.
150. (Previously Presented) The protein according to Claim 143, wherein the mutation is V44J.
151. (Previously Presented) The protein according to Claim 143, wherein the mutation is L45J.
152. (Previously Presented) The protein according to Claim 143, wherein the mutation is Q46J.
153. (Previously Presented) The protein according to Claim 143, wherein the mutation is G47J.
154. (Previously Presented) The protein according to Claim 143, wherein the mutation is V48J.
155. (Previously Presented) The protein according to Claim 143, wherein the mutation is L49J.
156. (Previously Presented) The protein according to Claim 143, wherein the mutation is P50J.
157. (Previously Presented) The protein according to Claim 143, wherein the mutation is A51J.
158. (Previously Presented) The protein according to Claim 143, wherein the mutation is L52J.
159. (Previously Presented) The protein according to Claim 143, wherein the mutation is P53J.
160. (Previously Presented) The protein according to Claim 143, wherein the mutation is Q54J.

161. (Previously Presented) The protein according to Claim 143, wherein the mutation is V55J.
162. (Previously Presented) The protein according to Claim 143, wherein the mutation is V56J.
163. (Previously Presented) The protein according to Claim 143, wherein the mutation is C57J.
164. (Previously Presented) The protein according to Claim 143, wherein the mutation is C88J.
165. (Previously Presented) The protein according to Claim 143, wherein the mutation is Q89J.
166. (Previously Presented) The protein according to Claim 143, wherein the mutation is C90J.
167. (Previously Presented) The protein according to Claim 143, wherein the mutation is A91J.
168. (Previously Presented) The protein according to Claim 143, wherein the mutation is L92J.
169. (Previously Presented) The protein according to Claim 143, wherein the mutation is C93J.
170. (Previously Presented) The protein according to Claim 143, wherein the mutation is R94J.
171. (Previously Presented) The protein according to Claim 143, wherein the mutation is R95J.
172. (Previously Presented) The protein according to Claim 143, wherein the mutation is S96J.

173. (Previously Presented) The protein according to Claim 143, wherein the mutation is T97J.

174. (Previously Presented) The protein according to Claim 143, wherein the mutation is T98J.

175. (Previously Presented) The protein according to Claim 143, wherein the mutation is D99J.

176. (Previously Presented) The protein according to Claim 143, wherein the mutation is C100J.

177. (Previously Presented) The protein according to Claim 143, wherein the mutation is G101J.

178. (Previously Presented) The protein according to Claim 143, wherein the mutation is G102J.

179. (Previously Presented) The protein according to Claim 143, wherein the mutation is P103J.

180. (Previously Presented) The protein according to Claim 143, wherein the mutation is K104J.

181. (Previously Presented) The protein according to Claim 143, wherein the mutation is D105J.

182. (Previously Presented) The protein according to Claim 143, wherein the mutation is H106J.

183. (Previously Presented) The protein according to Claim 143, wherein the mutation is P107J.

184. (Previously Presented) The protein according to Claim 143, wherein the mutation is L108J.

185. (Previously Presented) The protein according to Claim 143, wherein the mutation is T109J.

186. (Previously Presented) The protein according to Claim 143, wherein the mutation is C110J.

187. (Previously Presented) The protein according to Claim 143, wherein the mutation is D111J.

188. (Previously Presented) The protein according to Claim 143, wherein the mutation is D112J.

189. (Previously Presented) The protein according to Claim 143, wherein the mutation is P113J.

190. (Previously Presented) The protein according to Claim 143, wherein the mutation is R114J.

191. (Previously Presented) The protein according to Claim 143, wherein the mutation is F115J.

192. (Previously Presented) The protein according to Claim 143, wherein the mutation is Q116J.

193. (Previously Presented) The protein according to Claim 143, wherein the mutation is D117J.

194. (Previously Presented) The protein according to Claim 143, wherein the mutation is S118J.

195. (Previously Presented) The protein according to Claim 143, wherein the mutation is S119J.

196. (Previously Presented) The protein according to Claim 143, wherein the mutation is S120J.



197. (Previously Presented) The protein according to Claim 143, wherein the mutation is S121J.
198. (Previously Presented) The protein according to Claim 143, wherein the mutation is K122J.
199. (Previously Presented) The protein according to Claim 143, wherein the mutation is A123J.
200. (Previously Presented) The protein according to Claim 143, wherein the mutation is P124J.
201. (Previously Presented) The protein according to Claim 143, wherein the mutation is P125J.
202. (Previously Presented) The protein according to Claim 143, wherein the mutation is P126J.
203. (Previously Presented) The protein according to Claim 143, wherein the mutation is S127J.
204. (Previously Presented) The protein according to Claim 143, wherein the mutation is L128J.
205. (Previously Presented) The protein according to Claim 143, wherein the mutation is P129J.
206. (Previously Presented) The protein according to Claim 143, wherein the mutation is S130J.
207. (Previously Presented) The protein according to Claim 143, wherein the mutation is P131J.
208. (Previously Presented) The protein according to Claim 143, wherein the mutation is S132J.

209. (Previously Presented) The protein according to Claim 143, wherein the mutation is R133J.

210. (Previously Presented) The protein according to Claim 143, wherein the mutation is L134J.

211. (Previously Presented) The protein according to Claim 143, wherein the mutation is P135J.

212. (Previously Presented) The protein according to Claim 143, wherein the mutation is G136J.

213. (Previously Presented) The protein according to Claim 143, wherein the mutation is P137J.

214. (Previously Presented) The protein according to Claim 143, wherein the mutation is S138J.

215. (Previously Presented) The protein according to Claim 143, wherein the mutation is D139J.

216. (Previously Presented) The protein according to Claim 143, wherein the mutation is T140J.